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SNOW DAMAGE TO CONIFEROUS SEEDLINGS AND SAPLINGS

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Heavy snow fell on upper slopes of the Cascade Range during late winter and early spring of 1964, and lower than normal spring temperatures retarded snowmelt (U.S. Weather Bureau 1964). Summer temperatures also were low, and areas normally free of snow by July retained snow until mid-August or even through the entire summer. As a result, trees bore large accumulations of snow for longer than average periods of time. Many of them were injured.

OBSERVATIONS

During the 1964 growing season, general observations were made of snow damage to and recovery of young conifers growing on several old cutovers in upper-slope forests. All cutovers contained young, open, mixed stands of conifers, generally Pacific silver fir *(Abies amabilis)*, Douglas-fir *(Pseudotsuga menziesii)*, noble fir *(Abies procera)*, western hemlock *(Tsuga heterophylla)*, and western white pine *(Pinus monticola)*. Douglas-fir, Pacific silver fir, and western hemlock were usually most abundant. Species composition on the cutover areas generally mirrored that of the surrounding mature stands.

More detailed observations were made of free-growing seedlings on one cutover--Lava Lakes unit 9 near the Santiam-Clear Lake highway junction in the central Oregon Cascades. Seedling damage was rated as follows:

None	No visible injury
Very light . . .	Stem slightly bent or one to several lateral branches stripped from stem
Light	Stem bent severely; one to several lateral branches may be stripped from stem
Moderate	Stem fractured; one to several lateral branches may be stripped from stem
Severe	Stem broken off

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Ratings were made before 1964 height growth began, except for western white pine whose growth elongation started a week or two before snowmelt permitted access to the area. The same seedlings were measured for height growth during the 1963 and 1964 seasons for another study. This permitted relating snow damage to height growth. However, lack of trees in some ratings and failure of some terminal buds to elongate in 1964 prevented tests of statistical significance.

SNOW DAMAGE

Leaning, bent, and fractured stems and broken branches were common on many trees after snowmelt. Some tree species and tree sizes suffered more damage than others. Few trees below 4 feet were damaged by snow. Damage was most severe on trees from 4 to 20 feet in height. Occasionally, pole-size trees sustained a broken top or were stripped of a few branches. Trees of sawtimber size were uninjured except for a few broken branches.

In upper-slope forests, Douglas-fir seedlings and saplings were injured most severely. At Lava Lakes, Douglas-fir was the only species in the severe damage class--25 percent of the trees studied (table 1). Many Douglas-firs had fractured or broken stems, with fractures often occurring at several places along the stem. Some stems were broken off. Recovery of fractured or bent stems was noticeable approximately 1 week after bud bursting, and in 3 to 4 weeks stems were nearly straight (fig. 1). Apparently some of the food reserves accumulated during the previous fall and winter were translocated to the bent areas of the stem and helped to straighten the stem rather than to increase height growth. This was indicated by the average reduction in height growth of Douglas-firs in 1964 being inversely proportional to damage intensity (table 1).

In general, noble fir saplings suffered fewer snow injuries than did Douglas-fir, but more than western hemlock, western white pine, and Pacific silver fir in many upper-slope areas. Some noble fir poles had broken tops, but they were infrequent. On Lava Lakes unit 9, most noble fir injuries consisted of bent leaders or stems (fig. 2); no stem fractures were seen. Failure of terminal buds to elongate on several study trees in 1964 obscured any relationship between damage intensity and reduced height growth.

Few western hemlocks were seriously damaged by snow. However, one at Lava Lakes suffered moderate injuries consisting of fractures at several places along the stem. It recovered by the end of the growing season (fig. 3). It was common for pressure of snow to cause hemlocks to lean, but the trees recovered completely by the second to third week of the growing season. It appears that the supple stems of this species tolerate heavy snow without breaking. Height growth of hemlock apparently was not affected as much as associated tree species by snow damage. Actually, the 1964 rate of height growth of many hemlocks increased over that of 1963 (table 1).

Table 1.--Average 1963 and 1964 height growth for trees rated according to degree of snow damage observed at the Lava Lakes plot

Tree species	Snow damage ratings, spring, 1964	Trees studied	Mean height growth		
			1963	1964	$\frac{1964}{1963} \times 100$
		Percent	----- Cm ----		
Western white pine	None	18.2	30.8	38.8	126.0
	Very light	54.5	43.7	37.9	86.7
	Light	18.2	44.4	37.1	83.6
	Moderate	9.1	58.4	30.5	52.2
	Severe	--	--	--	--
Western hemlock	None	33.3	14.0	29.1	207.8
	Very light	33.3	30.5	24.9	81.6
	Light	25.0	16.0	29.1	181.9
	Moderate	8.4	62.6	14.0	22.4
	Severe	--	--	--	--
Pacific silver fir	None	--	--	--	--
	Very light	57.1	35.2	23.9	67.7
	Light	35.7	33.7	22.1	65.6
	Moderate	7.2	28.0	17.0	60.7
	Severe	--	--	--	--
Douglas-fir	None	--	--	--	--
	Very light	8.3	28.5	31.4	110.2
	Light	41.7	28.6	22.5	78.6
	Moderate	25.0	35.5	16.1	45.3
	Severe	25.0	38.5	4.3	11.1
Noble fir	None	--	--	--	--
	Very light	45.5	39.8	17.4	43.7
	Light	54.5	43.6	26.0	59.6
	Moderate	--	--	--	--
	Severe	--	--	--	--

Figure 1.--Recovery of a Douglas-fir sapling fractured in two places: A, Appearance on July 4, 1964, before bud flushing; B, approximately 2 weeks later, 1 week after bud flushing; C, recovered tree on September 12, 1964, 2 weeks after height growth had ceased. This moderately damaged tree grew 41.0 centimeters in height during 1963, only 14.2 centimeters in 1964.

Figure 2.--A lightly damaged noble fir and its subsequent recovery and height growth compared with that of an adjacent very lightly damaged western white pine: A, The two trees late in 1963; B, appearance on July 4, 1964, 1 week after bud break on the noble fir--the 1963 noble fir leader was severely bent by snow, the pine's leader was only slightly bent; C, recovery after several weeks (July 18, 1964); and D, by the end of the 1964 growing season.

Figure 3.--A, Undamaged western hemlock sapling in late 1963; B, the same tree on July 18, 1964, 4 weeks after bud break--stem was fractured in three places; C, same sapling at the end of the 1964 growing season. The tree grew 62.6 centimeters in 1963 and only 14.0 centimeters during 1964.

Western white pine was not heavily damaged by the snow. Common injuries seen at Lava Lakes were bent stems on some trees (fig. 4A) and stripped lateral branches on others. All Pacific silver firs at Lava Lakes suffered some damage, but injuries were mainly bent stems that recovered by the end of the growing season (fig. 4B). The 1964 height growths of damaged trees of these two species were generally less than in 1963 (table 1).

Figure 4.--A, Very light snow damage on a western white pine. The injuries were mainly bent stems. B, Tree on right shows the common type of injury on Pacific silver fir.

DISCUSSION

A high percentage of seedlings growing in several high-elevation areas in the Cascade Range were injured by large snow accumulations during the winter of 1964. Approximately 90 percent of those observed and measured on Lava Lakes unit 9 suffered various intensities of damage. Tabulation of the 1963 and 1964 height data of damage-rated trees indicated differences between tree species in the amount of damage suffered. This was shown by the percentage of study trees of a particular species in each rating and by reductions in the 1964 height growth compared with the 1963 growth of the injured trees. Reductions in height growth were generally commensurate with damage intensity.

Watt (1951) compared the 1948-49 winter damage with western white pine, western hemlock, grand fir *(Abies grandis)*, and other species including Douglas-fir growing in association on plot 14, Deception Creek Experimental Forest, Idaho. He observed that all species were about equally damaged. However, Douglas-fir observed in this study in the Cascade Range suffered more snow damage than any of its associated species.

Planting true firs, pure or in mixture with Douglas-fir, is recommended in the Douglas-fir region of the Pacific Northwest at elevations where noble fir or Pacific silver fir naturally occur mixed with the Douglas-fir (Douglas-fir Second-Growth Management Committee 1947). These true firs are considered more resistant than Douglas-fir to snowbreak and winter injury. Observations reported here support this recommendation.

Western hemlock suffered the least snow damage of any species at Lava Lakes. Few bent or fractured trees of this species were seen. Also, although there was considerable variation, the 1964 height growth increased on two-thirds of the measured hemlocks, whereas, it was generally reduced on associated species. Since an acceleration in height growth is expected from seedlings and saplings growing in the uncrowded conditions of the cutovers, an actual reduction is especially important. Height growth of all measured "undamaged" trees was not reduced in 1964.

Perhaps the most surprising development observed was the rapid recovery made by the damaged trees. In most cases, severely bent trees and those with fractured stems had straightened by the third week of bud elongation. Lateral branches on trees whose main stems were broken had turned upward and were competing for tree dominance by the end of the growing season. Presumably, only the trees which suffered broken stems would have any lasting deformity.

Similar observations on tree recovery were reported by Fenton (1959). He observed that most 3- to 6-year-old Virginia pine *(Pinus virginiana)* seedlings, severely bent by heavy snows the previous winter,

returned to a near-normal position during the first 2 months of the growing season. Although snow injury was minor to seedlings, saplings were severely damaged. Fenton believes that basal sweep, a defect common to larger Virginia pine, may be due to snow damage early in the life of the tree. Basal sweep is often seen on seedlings and saplings in the upper-slope forests of Washington and Oregon.

Since none of the study trees were cut, formation of reaction wood induced by heavy snow load was not observed. Young upper-slope conifers are often subject to heavy snow loads and consequent bending. Compression wood forms on the underside of bent trees and helps straighten the stem (Brown et al. 1949). Trees which are unable to straighten themselves form this wood indefinitely (Paul 1959). Since most trees observed in this study recovered quickly, compression wood formation will not be a major defect unless damage occurs repeatedly.

Snow damage may become more of a problem in upper-slope forests as management of these forests is intensified. Douglas-fir, a species observed here to be more susceptible to snow damage than its associates, is currently used to regenerate most upper-slope cutovers. Literature on snow damage shows that degree and timing of thinning can influence amount of damage. Generally, newly thinned--particularly, heavily thinned--sapling stands are especially vulnerable. Trees become more resistant to snow damage as their root systems expand and stems become stouter. Frequent, light thinnings, beginning at an early age, will help make stands more resistant to snow breakage and windfall (Rosenfeld 1944; Zeidler 1944; Roe and Stoeckeler 1950).

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